SOIL MOISTURE RESPONSES TO BLUESTEM BURNING

by

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INTRODUCTION

For ages man has been burning grasslands (Stewart, 1956). Ancient man not only used fire as a source of heat but also used it for protection against wild animals. The use of fire as a weapon to drive and kill game was probably employed a great deal by early man. He also used fire as a weapon of war.

The American Indian burned the prairie to aid him in hunting. Accidental fires often occurred on hunting expeditions when campfires were left burning. The Indian found that the new growth of forage which followed burning attracted grazing animals. This resulted in the practice of burning old grass tops to attract buffalo.

When the white man settled the prairie he also destroyed the old topgrowth with fire. Early ranchers and cattlemen noted increased gains by livestock pastured on burned ranges. Burning as an annual managerial practice became established. It was considered to be a cure for all range problems. Burning was believed by many to control weeds, harmful insects, and patchy grazing. Experimental studies have since shown that burning is of little value in weed control and is of no value in eleminating harmful insects or patchy grazing. The chief reason given for burning is that cattle gain more and go to market faster.

Conservation is the best argument against burning. Fire leaves the soil bare and unprotected. More water runoff and soil erosion are apt to occur. If more water runs off, less remains to enter the soil. Since water is considered to be a limiting factor in plant growth on the prairie, such runoff loss would cause a reduction in forage yield. Over

a long period of time, if stocking rates were not reduced, overutilization and overgrazing would result. A reduction in the stocking rate would result in smaller monetary returns to the rancher. Thus, a practice that shows financial increase for a short period might be costly in the long run.

Differences in water infiltration may be shown indirectly in soil moisture samples. This study was conducted to gain further information on the effects of burning and different burning dates on soil moisture. Moisture readings were taken throughout the growing season to give a picture of the seasonal fluctuations that occur at the various depths and in the different treatments.

REVIEW OF LITERATURE

The importance of moisture to grasslands can not be overemphasized. Weaver and Albertson (1944) stressed the importance of soil moisture as a limiting factor of plant production in the mixed prairie. Dyksterhuis and Schmutz (1947) stated that the chief factor limiting growth in the grasslands was water supply. They stated that the water supply was largely limited by the amount of water entering the soil and considered mulch as the primary factor in determining infiltration of rain water. They concluded that the most practical means of increasing the supply of water available for plant growth was to allow greater infiltration of the precipitation.

The value of mulch and top growth in conserving soil moisture has been shown by many workers. Hopkins (1954), comparing mulched and bare grassland soils in western Kansas, found that a half-inch of mulch

reduced evaporation 41 percent. He reported that September rains penetrated the mulched soils to a depth of four feet while the penetration of the bare soils went only to the two-foot depth.

Tomanek (1948) compared the soil moisture of the upper two feet of soil in moderately and heavily grazed pastures in August. He found three to seven inches of available moisture in the moderately grazed pasture and none in the heavily grazed one. Heavily grazed pastures have much smaller quantities of mulch.

Stephenson and Schuster (1945), working in the orchard area of western Oregon, stated that the moisture saved by organic mulches may be equivalent to one or two additional rains. They compared straw-and trash-mulched treatments with sod, scraped soil, and spaded, rough soil. They reported that two or three inches of moisture were saved on the straw-mulched plots. They also noted an increase in larger water-stable soil aggregates under the mulched treatments. Corroborating earlier studies Ellison (1944) reported that the breaking down of soil aggregates was one of the actions of raindrop splash. He stated that vegetal canopies and mulches impeded the fall of raindrops and soil movement due to raindrop splash.

Work done by Lowermilk (1930) showed that forest litter reduced runoff long after the litter was saturated with water. He stated that in the absence of mulch suspended particles in runoff water filtered out at the soil surface and sealed the pores and seepage openings. He concluded that the capacity of litter to absorb rainfall was insignificant in comparison with its ability to maintain the maximum percolating capacity of the soil.

In his water infiltration studies in the Bighorn National Forest, Rauzi (1954) observed little difference in water intake between lightly, moderately, and heavily grazed areas during the first 30 minutes. However, during the second 30 minutes the rate varied with the different degrees of grazing protection. The rate of intake on the lightly grazed area was about 40 percent higher than that of the heavily grazed one.

Duley and Kelley (1939) reported that soils covered with mulch gave a much higher rate of water intake than did bare soils. They found that the rate of intake on closely clipped sod with all debris removed was similar to that on bare soil. They reported that the infiltration rate on tilled soils covered with a mulch was at least as high as that on soils protected by a dense-growing crop. On bare, unprotected soils they noted a breaking down of soil structure by the compacting effect of rain. They stated that the compaction of soil particles at the soil surface appeared to be a principal reason for reduced water infiltration.

Weaver and Rowland (1952) reported that a thick mulch promoted water infiltration and retarded soil water evaporation. However, they also noted that much rainfall interception occurred on extremely heavily mulched areas. They found that as much as one-third of an inch of rain could be held above the soil in a heavy mulch.

Buetner and Anderson (1943), working on rangeland near Tucson, Arizona, compared water loss on mulched and untreated, clipped, perennial short grass plots. They reported 31 percent runoff on the untreated plot and only 9.2 percent on the mulched plot. They noted that the grass plot without mulch lost 20 percent more water than the

mulched plot and produced less than half as much forage. They concluded that a 20 percent increase in water conservation could increase forage production 50 percent.

Most of the preceding studies dealt with mulch and its influence on soil moisture. Some of the studies showed the effects of different grazing treatments upon soil moisture. There is a direct relationship between grazing and mulch cover. In comparisons between lightly, moderately, and heavily grazed pastures, Ratcliffe (1958) found consistently low mulch yields on the heavily grazed pastures. Mulch, then is not only of value in conserving moisture but also in indicating past range use.

Fire destroys mulch. The following studies deal with the influence of burning on mulch and soil moisture. Rowe (1941), working on California rangelands, stated that one of the most apparent results of burning was the increase in surface runoff. He reported a reduction of 90 to 95 percent in the infiltration capacity of the soil after burning. He stated that this was brought about by (1) the destruction of soil cover, (2) the reduction of organic matter in the surface soil, (3) a reduction in the activity of earthworms and burrowing insects, and (4) the plugging of soil pores and the destruction of soil structure.

The results of Scott (1956) did not agree. He reported that burning did not reduce the infiltration rates of the California and Nevada range soils that he tested. However, his method of measuring was the use of infiltration rings shortly after burning. This method did not take into consideration the longer time effects of raindrop splash that have previously been mentioned.

Penfound and Kelting (1950), working in Oklahoma, found that soil moisture was not influenced appreciably by winter burning. However, in their experiment much of the lower plant material was covered with snow and was protected from the fire. Therefore, although the pasture was burned, enough mulch remained to aid in water infiltration.

Aldous (1934) observed that burning reduced yields of mature bluestem vegetation. His work not only showed differences in moisture content between burned and unburned plots but also among some of the different burned plots. Plots were burned in the late fall, early spring, midspring, and late spring. Soil moisture samples were taken on all plots in May, June, and September in 1928, a year with favorable rainfall. Only the June sampling of the upper foot of soil in the fall-burned plot showed any deficiency of soil moisture.

In 1933, a hot, dry year, moisture samples were taken in June, August, and November. On the June sampling date Aldous reported that the moisture content was approaching the critical amount needed for plant growth. At this time the soil moisture of the check plot was 30 percent higher than that of the fall-burned plot. Firing was noted on the tips of some of the leaves of plants growing in the fall-burned plot. By August firing was noted in all of the burned plots, the most severe being observed in the fall-burned plot. The check plot showed no noticeable damage from firing.

Aldous further reported that some rain fell before the November sampling, after which all of the plots showed an increase in moisture percentage. It was observed that moisture increase was greater on the check and the late-spring-burned plots than on those burned earlier.

Hanks and Anderson (1957) studying Kansas bluestem pasture plots, gave evidence that burning at any time decreased water intake.

They found that in the spring all of the burned plots were lower in soil moisture than the checks regardless of the date of burning. Plots were burned in the late fall, early spring, midspring, and late spring. In the spring of 1955 it was found that late-fall burning, compared with the check plots, reduced available water in the upper five feet of soil from 6.5 inches to 1.05. The amounts of available water in the other burned plots were between those two extremes.

Results obtained in the spring of 1956 and 1957 were similar. However, the differences were not quite so striking.

Two weeks of wet weather in the fall of 1955 gave Hanks and Anderson an opportunity to check the influence of burning on water intake. Between September 30 and October 14, 4.47 inches of rain fell, of which 3.37 came in a single storm on October 4. Soil moisture samples were taken on October 14 and the percent of the 4.47 inches of rain that was stored in each of the plots was calculated. The results showed that the percent stored in the check plot was over twice that stored in the late-fall, early spring, and mid-spring-burned plots. The percentage of the rain stored in the late-spring-burned plots, although much lower than that on the checks, was higher than that on any of the other burned plots. Hanks and Anderson concluded that about 2.5 inches of the 4.47 inch rain was lost as runoff from the burned plots while less than ¼-inch was lost from the unburned plots.

Hanks and Anderson also conducted some infiltration tests in 1955 with a device that applied water artifically to the soil. They found that the rate of water intake dropped off more quickly in the late fall and midspring-burned areas than it did in the unburned check plot. No difference was noted between the two burned plots tested. They observed a reduction in forage yield due to burning in 1955 and 1956. The reduction due to late-spring burning was slight in 1956. In both years the late-spring-burned plots outyielded the other burned treatments.

MATERIALS AND METHODS

Experimental Area

The experimental area used for this experiment was the same as the one studied by Aldous (1934) and Hanks and Anderson (1957). The plots were established by Aldous in 1927. At that time the study was set up to observe the effects of annual and biennial burning. In 1951 the experimental design was changed and all burning since then has been yearly. Since 1950 the general date of burning has been kept constant on each plot.

The experimental area is located on a comparatively level ridge top about one mile north of the Kansas State University campus. The range classification of the soil is ordinary upland. The land, although tillable, has always been in grass.

There were ten plots in the experiment, two replications of five treatments each. The treatments were winter burning (about December 1), early-spring burning (about March 20), mid-spring burning (about

April 10), late-spring burning (about May 1), and the unburned check.

The climate of the area is typical of that of the true prairie. The average rainfall is about 32 inches. Rainfall by months during the experiment and the average rainfall for those months are shown in Fig. 1. Cooler temperatures than normal prevailed during most of the growing season. Table 1 shows the monthly average during the growing season and the long-time averages for those months.

Table 1. Monthly mean temperatures of 1959 compared with long time averages.

	April	May	June	July	Aug.	Sept.	Oct.
Mean temperatures 1959	54.3	67.0	75.4	75.5	82.3	68.8	53.3
Long-time average temperatures 1931-1955	55.5	64.6	75.6	81.2	79.6	70.8	59.3

Weather data were taken from the records of the Manhattan No. 2 weather station.

The vegetation of the experimental area is typical of that of the true prairie and Flint Hills. Big bluestem (<u>Andropogon gerardi</u> Vitman) and little bluestem (<u>Andropogon scoparius</u> Michx.) were the major species found on the plots. Some other plants commonly found were indiangrass (<u>Sorghastrum nutans</u> (L.) Nash), sideoats grama (<u>Bouteloua curtipendula</u> (Michx.) Torr.), prairie junegrass (<u>Koeleria cristata</u> (L.) Pers.), and showywand goldenrod (<u>Solidago speciosa</u> Nutt var. <u>angusta</u> T and G.)(Fernald, 1950).

EXPLANATION OF PLATE I

Fig. 1. Monthly precipitation for 1959 and 1931-1955 average, Manhattan, Kansas.

PLATE I

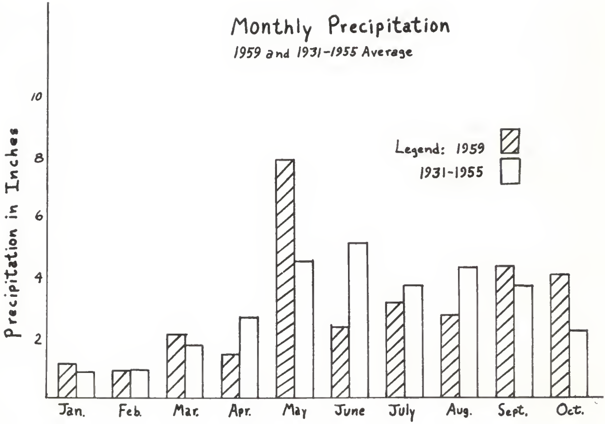
Monthly Precipitation
1959 and 1931-1955 Average
Precipitation in Inches
10
8
6
4
2
Legend: 1959
1931-1955
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.

Fig. 1.

Sampling Methods

Moisture readings were taken on thirteen different dates throughout the growing season. These readings were taken in each plot at depths of about 6 inches, 1.5, 2.5, 3.5, and 4.5 feet and gave approximate moisture percentages for the 1st, 2nd, 3rd, 4th, and 5th foot of soil. These percentages were then changed to inches of water per foot of soil.

The moisture readings were taken with a neutron moisture gauge. This gauge consisted of a moisture probe and a portable scaler or counter. The moisture probe was lowered into an aluminum access tube which had been placed near the center of each plot, and moisture readings were taken at the five different depths sampled.

The manufacturer, the Nuclear-Chicago Corporation, explains the theory of the neutron moisture probe as follows:

> Moisture measurements are based on physical laws governing the scattering and moderation of neutrons. When a radioactive source of fast neutrons is placed in a material, the neutrons collide with the nuclei of surrounding atoms and are scattered in all directions. Each collision by a neutron causes a loss of part of its kinetic energy. The scattering and energy reduction continues for a neutron until its kinetic approaches the average kinetic energy of the atoms in the scattering medium. At this low energy level, the neutron is designated a slow neutron.
>
> The average energy loss by fast neutrons is much greater in collisions with atoms of low atomic weight than in collisions involving heavier atoms, and hydrogen is the only element of low atomic weight found in most inorganic materials. The moisture probe is constructed with a special detector which is unaffected by fast neutrons or other radiation, and detects only slow or moderated neutrons. Therefore, the number of moderated neutrons detected per unit of time is also a measure of the concentration of hydrogen atoms in the material.

> Since the hydrogen content of inorganic materials is largely contained in molecules of free water, the slow neutron count thus becomes a measure of the moisture content of the material.

Impulses from the moisture probe were recorded on the scaler. The reading of the scaler was then converted to a moisture percentage by the use of a percentage table. The moisture percentage was then changed to inches of water per foot of soil.

EXPERIMENTAL RESULTS

Soil moisture readings were taken at five, one-foot depth intervals on each of the thirteen sampling dates in 1959. These readings clearly showed a relationship between date of sampling and amount of soil moisture. Moisture readings were high in the spring, dropped off during the summer, and increased again in the fall. Figures 2-7 show this trend.

Another obvious relationship was noted between sampling depth and the amount of soil moisture. The soil moisture fluctuated much more at the one and two-foot levels than at the three-, four-, and five-foot levels. Early in the growing season the top foot had the highest water content. By July 9 it had the lowest. Over two inches of rain fell in the week prior to the July 18 sampling date. Then sharp increases in moisture in the upper foot were recorded. A week later the top foot again was drier than the deeper layers and continued to be so until the fall rains began in mid September. Figures 8-13 show the relationship between soil depth and moisture content.

Very little fluctuation occurred below the two-foot depth in any of the plots. After May the amount of soil moisture in the third, fourth,

and fifth foot of soil gradually declined until the fall rains. After late September and early October rains an increase in soil moisture was evident in readings taken at the third foot. However, little increase was noted in readings taken at the fourth and fifth-foot levels.

The general relationship between burning treatments and soil moisture was most noticeable at the start of the experiment. During the summer, differences in soil moisture among the treatments became less pronounced.

Differences were noted between the two replications. These were most evident in the check plots. The check plot in replication one was higher in moisture throughout the growing season than was the corresponding plot in replication two. Differences between the check plots increased until fall. Then a slight decrease was noted.

The average water content in the check plots was greater than that in any of the burned treatments at the beginning of the experiment. It continued to be so until late June. On June 23 little difference was noted among the averages of the checks, the late-spring-burned plots, and the mid-spring-burned plots. On July 9 the moisture content of the mid-spring-burned plots was less than that of the check and the late-spring-burned plots. However, after a 2.37 inch rain, the three were about equal again on the July 18 sampling date. In late July and early August the late-spring-burned plots and the checks averaged the highest in soil moisture content. By late August and in early September little differences due to the effects of the treatments could be shown. In October, after the fall rains had started, differences among treatments

EXPLANATION OF PLATE II

Fig. 2. 1959 seasonal fluctuations in soil moisture for the various burning treatments. Average for upper 5 feet of bluestem range soil.

Fig. 3. 1959 seasonal fluctuations in soil moisture for the various burning treatments in the first foot of bluestem range soil.

PLATE II

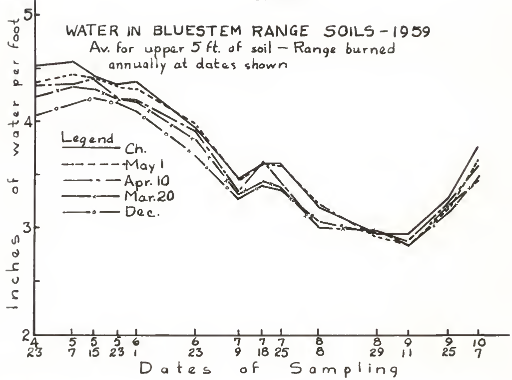

Fig. 2.

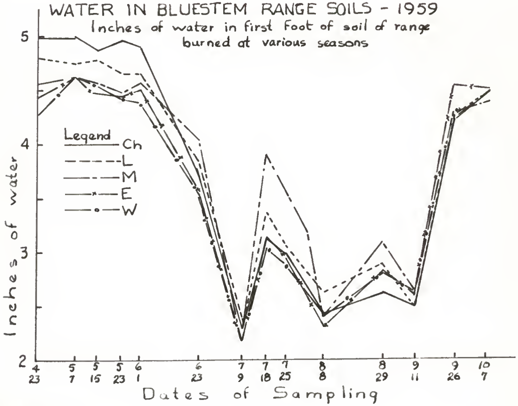

Fig. 3.

EXPLANATION OF PLATE III

Fig. 4. 1959 seasonal fluctuations in soil moisture for the various burning treatments in the second foot of bluestem range soil.

Fig. 5. 1959 seasonal fluctuations in soil moisture for the various burning treatments in the third foot of bluestem range soil.

PLATE III

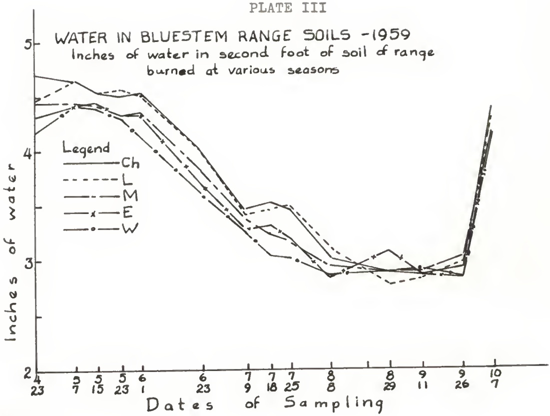

Fig. 4.

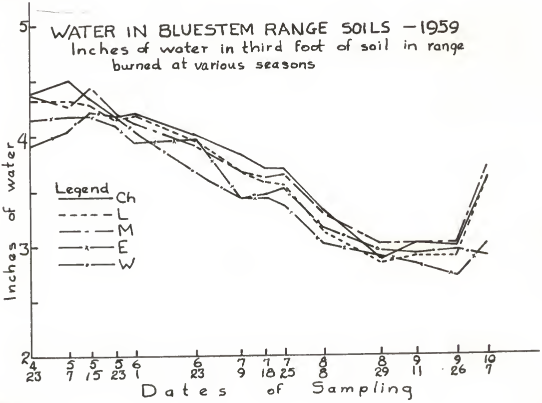

Fig. 5.

EXPLANATION OF PLATE IV

Fig. 6. 1959 seasonal fluctuations in soil moisture for the various burning treatments in the fourth foot of bluestem range soil.

Fig. 7. 1959 seasonal fluctuations in soil moisture for the various burning treatments in the fifth foot of bluestem range soil.

PLATE IV

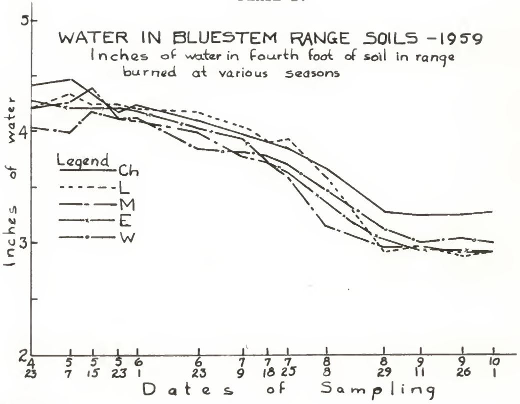

Fig. 6.

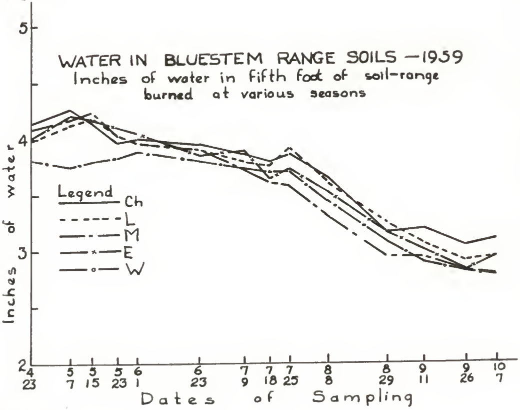

Fig. 7.

EXPLANATION OF PLATE V

Fig. 8. 1959 seasonal fluctuations in soil moisture at different depths for the average of all treatments.

Fig. 9. 1959 seasonal fluctuations in soil moisture at different depths for the winter-burned treatments.

PLATE V

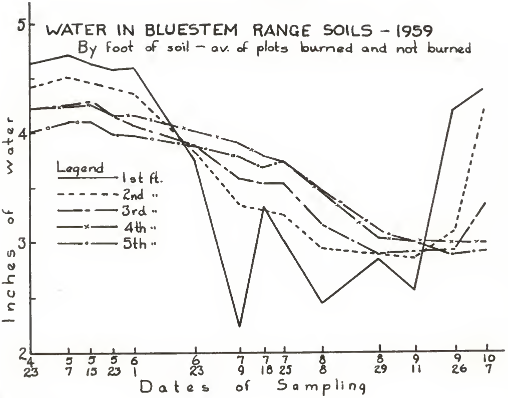

Fig. 8.

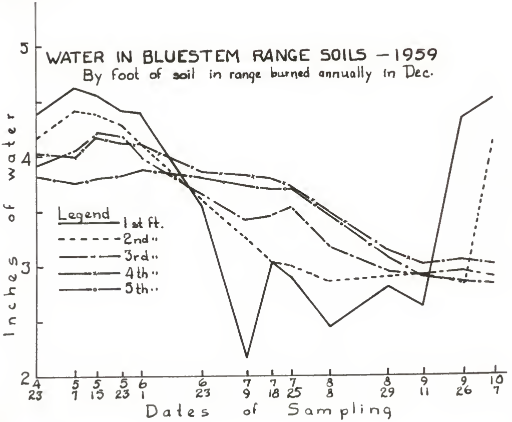

Fig. 9.

EXPLANATION OF PLATE VI

Fig. 10. 1959 seasonal fluctuations in soil moisture at different depths for the mid-spring-burned treatments.

Fig. 11. 1959 seasonal fluctuations in soil moisture at different depths for the early-spring-burned treatments.

PLATE VI

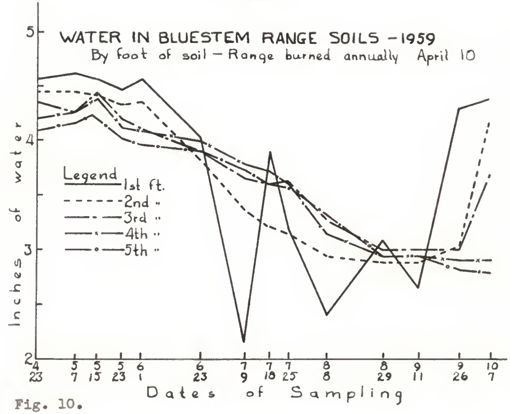

Fig. 10.

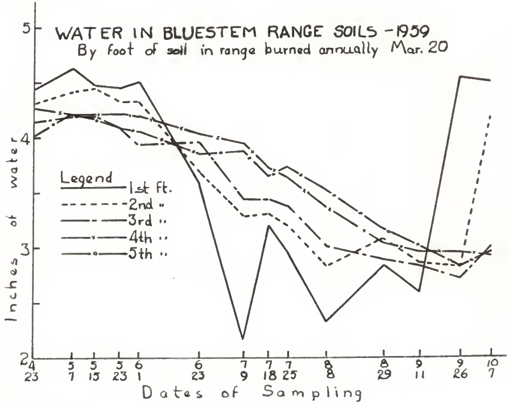

Fig. 11.

EXPLANATION OF PLATE VII

Fig. 12. 1959 seasonal fluctuations in soil moisture at different depths for the late-spring-burned treatments.

Fig. 13. 1959 seasonal fluctuations in soil moisture at different depths for the unburned checks.

PLATE VII

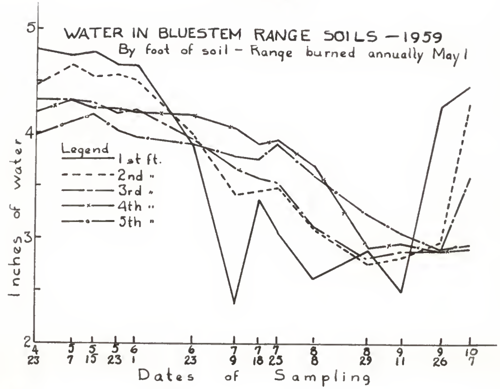

Fig. 12.

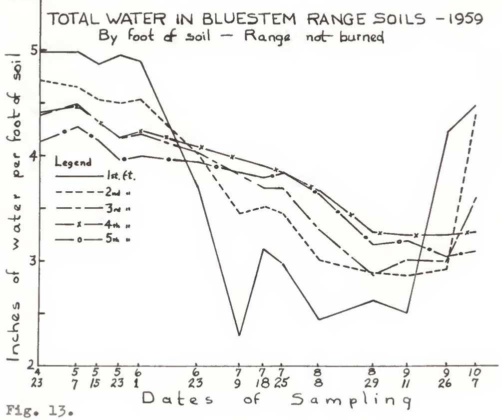

Fig. 13.

were again evident. On October 7 the average of the check plots was again higher than that of any of the other treatments.

The winter-burned and the early-spring-burned plots were the lowest in soil moisture throughout most of the growing season. Only in late August and early September did they compare with the checks and the late-spring-burned plots. This is shown in Figure 2.

Water increase in the soil was studied after three rainy periods. Moisture readings taken on July 18 after a week of wet weather showed increases in all plots. Soil moisture increase was calculated by substracting the moisture readings taken on the preceeding sampling date from those taken after the rains. This was done for each foot interval. On the June 18 sampling date the greatest increase was found in the mid-spring-burned plots. The increase was the lowest on the two winter-burned plots. Of the 2.37 inches of rain that fell in the week preceding the July 18 sampling date, the following amounts of soil moisture increase were found:

midspring-burned plots	1.74	inches
early-spring-burned plots	1.05	"
late-spring-burned plots	1.02	"
check plots	.90	"
winter-burned plots	.87	"

Between September 17 and September 26, 3.81 inches of rain fell. On the latter date moisture readings were taken and compared with the readings obtained on September 9. Average moisture increase per treatment was as follows:

early-spring-burned plots	1.95	inches
late-spring-burned plots	1.92	"
midspring-burned plots	1.80	"
check plots	1.77	"
winter-burned plots	1.74	"

Although there was little difference among treatments, the winter-burned plots again showed the smallest increase.

A third measure of water intake was taken on October 7. Between the September 26 and the October 7 sampling dates, 3.51 inches of rain fell. The average water increase by treatments was as follows:

check plots	2.49	inches
late-spring-burned plots	2.31	"
midspring-burned plots	1.95	"
early-spring-burned plots	1.77	"
winter-burned plots	1.47	"

These measurements showed greatest moisture increase in the check plots and the least increase on the winter-burned plots.

Table 2 shows the analysis of variance for the moisture readings taken throughout the growing season of 1959. Significance was found in replications, dates of sampling, depths, treatments, and in the interactions between dates and depths and between depths and treatments. The statistical procedures followed were those prescribed by Goulden (1952) in Methods of Statistical Analysis.

Table 2. Analysis of variance of soil moisture readings sampled throughout the growing season for various burning treatments and at different depths.

Source of variation	D.F.	MS	F
Replications	1	1.2122	25.63***
Dates	12	14.2450	301.16***
Depths	4	.2353	4.98***
Treatments	4	.7534	15.93***
Dates x depths	48	1.6208	34.27***
Dates x treatments	48	.0364	.77n.s.
Depths x treatments	16	.0767	1.62*
Dates x depths x treatments	192	.0246	.52n.s.
Residual	324	.0473	

* Indicates significance at the .05 level

*** Indicates significance at the .001 level

Table 3 shows the Duncan's New Multiple Range Test on the average amount of soil moisture in the various treatments. These averages are expressed as inches of water per foot of soil. This test indicates the treatments that differ significantly in average water content. It shows that all of the treatments differ with the exception of the late-spring burning and the unburned check. The averages are arranged in order of increasing moisture content.

Table 3. Duncan's New Multiple Range Test[a] on the soil moisture in the entire surface five feet of various burning treatments.

Number of observations per treatment	130				
Mean soil moisture readings	<u>3.53</u>	<u>3.58</u>	<u>3.63</u>	<u>3.68</u>	<u>3.72</u>
burning treatment[b]	W	E	M	L	C

a/ Any two means not underscored by the same line are significantly different (P.05). Any two means underscored by the same line are not significantly different.

b/ Symbols used are first letters of the treatments: W=winter burned; E=early-spring burned; M=mid-spring burned; L=late-spring burned; and C=unburned check.

Table 4 also indicates differences in soil moisture among the five treatments. The Duncan's Test was conducted on each foot of the five feet of soil tested. Means used in the table are averages from all of the sampling dates. This differs from Table 3 in that each foot of soil is tested separately.

Table 4. Duncan's New Multiple Range Test of soil moisture readings by each foot in different burning treatments.

Number of observations	26				
$\bar{x}$ 1st. ft.	3.56	3.62	3.67	3.71	3.71
Burning treatments	W	E	C	L	M
$\bar{x}$ 2nd. ft.	3.51	3.59	3.61	3.73	3.74
Burning treatments	W	E	M	L	L
$\bar{x}$ 3rd. ft.	3.45	3.48	3.61	3.73	3.74
Burning treatments	E	W	L	M	C
$\bar{x}$ 4th. ft.	3.61	3.63	3.63	3.72	3.82
Burning treatments	M	W	E	L	C
$\bar{x}$ 5th. ft.	3.47	3.54	3.61	3.63	3.68
Burning treatments	W	M	E	L	C

$\bar{x}$ indicates the average moisture content.

DISCUSSION AND CONCLUSIONS

It was shown in the analysis of variance that differences in replications, dates, depths, treatments, and interactions between dates and depths and between depths and treatments were significant. The significant differences between replications indicated that the two replications were not equal. That was quite evident when the two check plots were compared. The moisture content of the check plot in replication one was consistently higher than that of the corresponding plot in replication two. No difference in the past history was found, so past use cannot explain the difference between the two check plots. Yields taken in the fall of 1959 (Anderson, 1959) also showed differences between the check plots. The check in replication two outyielded the replication one check. Thus the check that was lower in moisture outyielded the other and the reduction in soil moisture could

be explained by the greater production of forage and consequent greater use of soil moisture. Differences in replications were not evident in the other treatments.

Differences in the amount of moisture among sampling dates were highly significant. During the hot, dry summer months, the moisture content in the top five feet of soil was reduced to two thirds of what it was at the beginning of the experiment. After the fall rains the moisture content increased in all of the plots. Thus rains or the lack of rain greatly influenced the variability from date to date.

Differences in soil moisture among depths were also significant. During the summer soil moisture reductions were much greater in the top two feet of soil than they were in the third, fourth, and fifth foot. Water losses due to evaporation and absorbtion by plants were much lower at the deeper levels. This was quite evident in early and late July. Fall rains also affected the variability from one depth to another. Most of the early fall rains were held in the surface two feet of soil while the fourth and fifth foot continued to decrease slightly in water content. Even after the rainy period in late September and early October in which over seven inches of rain fell, the fourth and fifth foot continued to decline in water content.

Differences in average soil moisture among the treatments were highly significant. These differences can be explained by differences in water evaporation, water uptake, and losses due to plant transpiration. By comparing the yields taken in the fall (Anderson, 1959) with the average soil moisture content of the treatments, it was found that the treatments averaging the lowest in soil moisture were also

the lowest yielding. Lower yields indicate less area in which transpiration can occur. Therefore, the low moisture content of the lower yielding treatments can not be attributed to greater transpiration losses. The lower yields were a result, not a cause, of the lower moisture content found on the lower yielding plots. Reduced rates of water infiltration, higher evaporation losses, or a combination of the two seem to be the reason for the lower water content.

It was evident that the winter-burned plots were the lowest in soil moisture throughout most of the growing season. Only in late August and in early September did their average moisture content compare with those of the other treatments. During those months the moisture levels of the other treatments dropped down to that of the winter-burned plots. A study of moisture increase after rains showed that the winter-burned plots were consistently the lowest.

Average moisture readings taken in the unburned and late-spring-burned plots were significantly higher than those of the other treatments. The checks and the late-spring-burned plots were not significantly different. Ideal conditions prevailed at the time of late-spring burning in 1959. The soil and lower leaves were moist from a recent shower when the plots were burned. The percentage of mulch destroyed by burning was probably not so great on them as on the other burning treatments. Also the period of time that the soil remained bare and unprotected was shorter on the late-spring-burned plots than on those burned earlier.

Measurements of increase in soil water were taken after three rainy periods. On three sampling dates, July 18, September 26, and October 7, the soil moisture in each plot was compared with its soil moisture on the preceding date of sampling. The increases varied because of differences in water uptake and water loss. Water losses due to plant transpiration varied among the treatments and among the sampling dates.

Although plant transpiration was not measured, the higher yields of the check plots indicate that there was more leaf area on them in which transpiration could occur. Therefore, the check plots probably lost more water by plant transpiration than did the lower-yielding, burned plots.

Seasonal differences in transpiration also occur. Measurements of increases of soil water calculated from samples taken in the summer were more greatly influenced by transpiration losses than were those taken on the cooler, fall sampling dates.

On the October 7 sampling date the transpiration losses were probably lower than on the earlier sampling dates. At that time the check plots showed the greatest increase in soil moisture.

The water increase in the winter-burned plots was the lowest after all three rains. Since their yields were lower than those of the other treatments it appears that they lost less water by plant transpiration than did the others. It can, therefore, be assumed that the winter-burned plots lost more water by runoff and evaporation than did the other treatments.

The interaction between sampling dates and depths was highly significant. Moisture readings from the first foot of soil were higher than those taken at other depths on some sampling dates and lower on others. This was due to the great fluctuation in soil moisture near the surface. Light rains often increased the water content of the top foot of soil but had little or no influence at the lower depths.

Interactions between dates and treatments were not significant. Moisture content in the check plots and the late-spring-burned plots was always at least as high as in the other treatments. On no sampling date did the averages of the checks or the late-spring-burned plots drop below those of the other treatments.

Interactions between depths and treatments were significant at the .05 level. This can be seen in Table 4. In the first foot of soil the average soil moisture content of the mid-spring-burned plots was significantly higher than that of the winter-burned plots and equal to the averages of the check, late-spring-burned, and early-spring-burned plots. However, at the fourth and fifth foot the average moisture content of the mid-spring-burned plots was significantly lower than that of the check and equal to that of the winter-burned plots.

SUMMARY

This study has been conducted in an effort to gain more information about the effects of pasture burning on soil moisture. The experiment was conducted on the old college pasture plots located about one mile north of the Kansas State University campus on the bluestem pasture of the Department of Animal Husbandry.

Four different burning dates and an unburned check were included in each of two replications. Soil moisture samples were taken with a neutron moisture gauge on thirteen different sampling dates throughout the growing season of 1959. Moisture readings were taken at each foot to the five-foot depth. Impulses recorded on the moisture meter were converted to inches of water per foot of soil.

Differences in soil moisture were noted on different dates of sampling, at different depths of soil, and for the different treatments. The unburned plots and the late-spring-burned plots were significantly higher in soil moisture than were theother treatments. The winter burned plots were the lowest.

Highest moisture readings were obtained from the check plots in the early spring. Later in the season the differences among treatments became smaller. In the late summer the lowest readings were recorded. No differences among treatments were noticeable at that time.

Differences in soil moisture among the various depths were also noted. Moisture levels in the top two feet fluctuated much more than those in the third, fourth and fifth foot.

Measurements of increases in soil water were taken after three rainy periods. The soil moisture in each plot was then compared with its soil moisture on the preceding sampling date. Results varied greatly because of differences in plant transpiration among the treatments and the sampling dates. It was found that the winter-burned plot showed the smallest water increase after all three of the rains.

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SOIL MOISTURE RESPONSES TO PASTURE BURNING

by

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The annual burning of native pastures is practiced throughout the Flint Hills. Arguments for and against burning have arisen. Weed control, prevention of patchy grazing, and increased gains per animal are the major reasons given for burning. In experiments only the last reason has been proven valid. Those who oppose burning claim that burning aggravates the weed problem and increases soil erosion and water runoff.

This study was conducted to gain more information about the effects of pasture burning on soil moisture. The experiment was located one mile north of the Kansas State University campus on ordinary upland range type. True prairie vegetation in excellent range condition covered the area.

Ten plots were divided into two replications of five treatments each. The treatments were winter burned (about December 1), and early-spring burned (about March 20), mid-spring burned (about April 10), late-spring burned (about May 1), and the unburned check. Soil moisture readings were taken at each foot to the five-foot depth with a neutron moisture gauge on thirteen different sampling dates. Impulses recorded on the scaler or counter were converted to moisture percentages and then to inches of water per foot of soil.

Differences in soil moisture were found on different dates, at different depths, and for the different treatments. The unburned plots and the late-spring-burned plots were significantly higher in soil moisture than were the other treatments. The winter-burned plots were the lowest.

Highest moisture levels were observed in the check plots at the beginning of the experiment, at which time the greatest differences among treatments occurred. In the late summer, when lowest moisture readings were recorded, no differences among treatments were noticeable.

Soil moisture differences among the various depths were also noted. Readings in the top two feet fluctuated much more than did readings from the third, fourth, and fifth foot levels.

Measurements of increases in soil water were taken after three rainy periods. On three sampling dates, July 18, September 26, and October 7, the soil moisture in each plot was compared with its soil moisture on the preceding date of sampling. Results varied greatly because of differences in plant transpiration among the sampling dates and among the treatments.